MISCELLANEOUS REPORT NO. 23

MANAGING NORTHERN HARDWOODS IN THE LAKE STATES

By Carl Arbogast, Jr., Forester

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Lake States Forest Experiment Station

April 21, 1953

Miscellaneous Report No. 23

MANAGING NORTHERN HARDWOODS IN THE LAKE STATES 1/

By Carl Arbogast, Jr.2/
Lake States Forest Experiment Station3/

The northern hardwood type confronts foresters in the Lake States with two problems: the management of old growth, predominantly sawtimber stands, and the management of second-growth stands, composed largely of trees below sawtimber size.

Many years ago, it was recognized that this timber type would be adaptable to partial cuts, since it is a climax type composed of tolerant species.4/ The type perpetuates itself with, or without, cutting, if fire is kept out. If there is fire, aspen, pin cherry or brush usually replace the northern hardwoods. But where seed trees from the original stand are left alive, the northern hardwoods soon re-establish themselves as an understory.

MANAGEMENT OF OLD GROWTH SAWTIMBER STANDS

The history of logging in the northern hardwood type is a story of partial cutting from the beginning. The early logging took chiefly the white pine. Very little hardwood was felled, except to clear land for settlements and to produce charcoal for the manufacture of iron. As time went on and the pine became scarce, the stands were relogged, in many cases, to remove the spruce, hemlock, or the more desirable hardwoods, according to their value. For example, in 1912, basswood was the most valuable species, followed by elm (mostly American), white ash, and finally yellow birch and sugar maple.4/ Between 1900 and 1920, the latter two species were cut more, usually by

---

1/ Paper presented at the annual meeting of the Wisconsin-Upper Michigan Section of the Society of American Foresters at Madison, Wisconsin on February 20, 1953.

2/ Forester in charge. Upper Peninsula Experimental Forest. Marquette, Michigan. The author acknowledges the aid of Messrs. Eyre, Zillgitt, Longwood, Engle, Stoeckeler, and other members of the station staff from whose reports he has drawn freely in preparing this paper.

3/ Maintained by the U. S. Department of Agriculture, Forest Service, in cooperation with the University of Minnesota, University Farm, St. Paul, Minnesota.

4/ Frothingham, E. H. The northern hardwood forest: its composition, growth and management. U. S. Dept. Agr. Bull. 285. 80 pp. Illus.

commercial clearcutting. Actually this was a partial cut because the loggers usually left at least 250 trees per acre below 12 inches d.b.h. or larger ones considered too defective to be worth taking.

In the nineteen twenties, many lumber companies began to realize that there was an excess of mill capacity over available stumpage and that they faced a limited future unless something was done. Some mills had to liquidate and go out of business. At the urging of foresters, timber owners began to make partial cuts aimed at preserving and extending the timber supply until second-growth stands reached sawlog size. At this time, also, the Cleveland Cliffs Iron Company, in the Upper Peninsula of Michigan, donated a half section of cut-over hardwoods and a half section of old growth hardwoods (upon which they retained cutting rights for 20 years - later extended to 40 years) to the Lake States Forest Experiment Station for research purposes. On this land, tests involving some eight methods of partial cutting were established between 1926 and 1932.

By the middle of the 1930s, following a period of cutting to higher diameter limits and "high-grading", it became generally accepted, among foresters at least, that the selection system was well suited to the northern hardwood type. It works satisfactorily and is commercially feasible. However, we still have much more to learn about its application. At present, there are over one million acres of hardwood land, in both public and private ownership, in the Lake States upon which a start towards sustained yield has been made. This is about one-half of the sawtimber area in the type.

There are many reasons, silvicultural and economic, why this system appears well suited to the northern hardwood type:

(1). Northern hardwoods are composed of tolerant species. Even though the most valuable species, yellow birch, is considerably less tolerant than the dominant sugar maple, only a slight modification of the basic system is needed to insure its establishment. This is done by creating small openings of about one-tenth acre within seeding distance of seed trees.

(2). Northern hardwoods respond well to release, even at advanced ages.

(3). Abundant natural reproduction develops after cutting. Planting or other costly measures seldom are needed.

(4). The type is very fire resistant; it will burn only under extreme conditions. The financial risk of losing the residual stand is greatly minimized by this fact.

(5). The type is highly resistant to insects and disease. Usually just maintaining the composition of species is enough to keep the forest healthy.

(6). The logging cost is less and the financial returns higher when mostly large logs are cut.

(7). The high value of choice logs makes individual tree marking possible.

(8). Retaining trees just approaching the size in which high grades will result has a decided economic advantage. These trees increase in value at about double the rate they increase in volume.

On the other hand, there are some difficulties, mostly economic, that work against complete acceptance of the selection system. Some of them are:

(1). The stands contain many large and overmature trees. Some of these usually must be left uncut to avoid over-large openings and to reseed the area. They represent a high value and a high risk. Economically it seems that they should be cut, but often the silvicultural advantage is the best economics in the long run.

(2). A large amount of cull and low grade products is found in old growth hardwood stands. Good practice demands that these be removed as rapidly as possible. Economically, these trees are marginal.

(3). There is not enough acreage and volume of timber to support the present sawmills on a sustained yield. This is probably the biggest single factor working against the selection system. The high investment in plants and mills exerts a strong pressure to keep them going at full capacity.

(4). There is a constant threat of higher taxes. For the last 10 to 15 years timberland owners who were trying to practice sustained yield forestry were treated fairly in the matter of property taxes. Recently, however, there is a tendency for local governments to put the squeeze back on the forest properties to finance schools and improvements.

(5). There is still uncertainty in the minds of the forest land owners as to how good a business sustained yield forestry actually is. They are more conscious of the risks involved, the investment tied up, the market uncertainty, etc., than they are of the continuous financial returns.

These disadvantages will probably be overcome as new products and new markets are developed. Until then, management practice will, of necessity, be a compromise between ideal silviculture and economics. The silviculturist will have the financial resources to do only what economics

will let him. The economist can go only so far in his realization of theoretical costs and returns as the laws of nature will let him. A forest manager must be both silviculturist and economist to do his job successfully.

The selection system, as used in this type, may be defined as an all-aged system of sustained yield forest management in which the growing stock is reduced to an optimum level for maximum quantity and quality growth by removing the defective, cull and high risk trees over the entire range of size classes and the mature and over-mature trees through partial cuts. Ideally, it is a system in which the harvest cut and all types of intermediate cuts are made at the same time, periodically.

When this system was first used in the northern hardwood type, the principles were understood, but little or nothing was known of the methods of application. For example, no one knew what was the optimum stocking level or how it should be measured; whether all defective, cull, and high risk trees should be removed, or just how to determine high risk and cull; or how big or old a sugar maple or yellow birch is when it is mature.

Stocking

When we started using the selection system, we had to talk the language of the logger and mill owner, in order to sell the idea that they could afford to cut selectively. It was natural, therefore, that we turned to a unit of measurement with which they were familiar, net board feet per acre, to express stocking level. We soon realized that this would not work. Volume is an expression of site. So if we were going to use volume as a stocking guide, we would also have to include some sort of site index as the stands varied from 4,000 to 15,000 net board feet per acre. We had no precise expression of such site indexes.

The next attempt to express stocking was in terms of the percent of the total net merchantable stand to be cut. For example, we spoke of "30 percent cuts" and "50 percent cuts." It was an improvement because now site was eliminated. Although this method is still used extensively, it has many disadvantages. Some of them are:

(1). It does not take into consideration the condition of the timber. A stand with much cull is actually cut heavier at a given percent than one with little cull. Using gross volume as a base would eliminate this difficulty.

(2). Net board feet measurements are very difficult to make in the forest, because only indirect methods can be used. No matter how carefully the basic measurements are made, large errors are possible because of the nature of the unit.

(3). The relationship between percent of cut and response to release does not hold very well except in localized areas. Twenty-five percent of 4,000 feet represents a lower stocking than 25 percent of 15,000 feet.

(4). The attention is focused on the amount to be cut when it should be on the trees to be left.

The use of basal area per acre as a unit of stocking now appears to eliminate many of the disadvantages previously mentioned. It can be accurately and simply measured. It is independent of site. It can include all the size classes in the stand, not just those sizes that are merchantable for sawlogs. And, finally, there is a very close correlation between residual basal area and volume growth.

Recent analysis of data collected on the old cutting plots at the Upper Peninsula Experimental Forest representing 15 to 25 years of observations, indicates that the following residual basal areas are close to optimum, for a 10 to 15 year cutting cycle:

65 to 70 sq. ft. per acre for trees 10 inches and over
80 to 85 sq. ft. per acre for trees 5 inches and over
or 90 sq. ft. per acre for trees 2 inches and over

Slightly lower stocking than that just mentioned gave the highest economic return on the growth of the residual stand while slightly higher stocking gave a larger volume growth. The figures quoted represent a reasonably satisfactory compromise between the two.

Risk and Culls

A discussion of risk could become involved, but I should like to discuss briefly whether cull trees should be removed from the stand. The species found in northern hardwood stands all live to ages of 350 years and more. Some of the cull trees are still vigorous and can be expected to live and grow for many years; others are high risk trees. Forest survey plots show about 14 sq. ft. of basal area per acre of cull trees 10 inches and over in the old growth stands in the Upper Peninsula. If we were to cut to the recommended stocking mentioned previously, that is 70 sq. ft., and leave the cull trees in the stand, then 20 percent of the residual stand would be in cull trees after cutting as opposed to about 10 percent before cutting. Most of the culls respond to release as well as merchantable trees. Therefore, the percentage of culls in the stand would be higher after each cut. The stand, instead of showing improvement in quality after each cut, would gradually deteriorate. The loss of quality growth justifies the killing or removal of the culls.

It has been said that cull trees in the residual stand are beneficial in that they prevent windthrow and help keep the crowns closed. Observations on the Argonne Experimental Forest in Wisconsin and on the Upper Peninsula Experimental Forest indicate that it is the type of tree in the residual stand, not the stocking, that makes a stand liable to wind damage. Stands in the Upper Peninsula with stocking as low as 30 sq. ft. of basal area per acre have stood through severe wind storms with less damage than adjacent uncut stands. A survey of wind damage after the storm of October 1949 showed about 8 times as much damage in the uncut stands on the Argonne Experimental Forest as in the selectively cut stands.

If the correct stocking level for the residual stand is used, we do not need cull trees to keep the crowns closed and protect the site. Good growing stock will be doing it in place of culls.

Maturity

The question of maturity has not been answered satisfactorily, as yet. It appears to be a matter of economics, rather than silviculture. The species in the northern hardwood type live for more than 350 years and reach 35 to 40 inches d.b.h. Some attempts have been made to determine the economic diameter limits to which northern hardwoods can be grown. One study, based on log grades, concluded that it was very doubtful if sugar maple could be grown larger than 19 inches d.b.h. with a 3 percent compound interest return on the investment. This conclusion was backed up by two other factors:

First - Merchantable height does not increase in trees above 19 inches d.b.h., so there is no point in holding a tree beyond this size in hopes of getting more logs.

Second - Production costs per M board feet decrease very little in trees over 19 inches.

An earlier study arrived at 20 inches as the economic limit. At that size the top log of the average tree is large enough for veneer. Because of the high value of the tree at this stage, it is impossible to earn as much as 3 percent compound interest by holding it any longer.

Finally, a third study based on lumber grade recovery concluded that 23 inches is about the maximum size that trees in northern hardwood stands can be grown for lumber and still earn 3 percent interest.

None of these studies are conclusive; however, they do indicate that 23 inches, and probably less, is the economic size to grow the trees. Of course, an owner who processes his own wood, or some public owners, can afford to grow timber at returns of less than 3 percent on a stumpage basis.

Stand Structure

There is one final point I want to discuss on old growth management. That is stand structure. Usually there is a lack of sapling-and pole-sized trees in uncut old growth. This has caused some people to doubt whether the cutting system now in use is really all-aged management or gradual liquidation. "I can see the next cut and the one after that, but then you will run out of timber" is a comment often made. While there is some justification for this fear, the situation is not too serious. When the cut is sufficiently heavy, the understory fills in rapidly. Probably the worst that could happen would be an adjustment in the management plan lengthening one of the cutting cycles to permit the deficient sizes to fill in. But it is doubtful that even this will be necessary.

Under selection management there must, of course, be continuous ingrowth. The optimum basal area must be properly distributed over the whole range of diameter classes to permit this.

MANAGEMENT OF SECOND GROWTH HARDWOODS

More than two-thirds of the northern hardwood type in Wisconsin and Upper Michigan is second growth. Private landowners, National Forests and industry are becoming increasingly aware of the older second growth stands as a potential source of high quality material in the future and a current source of income from low grade material such as chemical wood, pulpwood, low grade sawlogs, railroad ties, etc.

Two distinct types of second growth stands have resulted from different utilization standards at the time of logging. The areas that were cut for sawlogs only, have many all-aged characteristics, while those that were cut for sawlogs plus charcoal or chemical wood appear even-aged.

The stands of both types range from 10 to 80 years in age since cutting. Considerably more than one-half of them are less than 55 years old. Although many of the areas contain from 2 to 5 thousand board feet, or from 10 to 15 cords of chemical wood per acre, little cutting has been done in them, as yet.

The second growth forests of both types are in poor condition for maximum quantity and quality growth, and almost without exception, require intermediate cutting of some kind.

The stands cut for sawlogs only have the following undesirable characteristics:

(1). Large cull trees left during the original operation have head dominant positions in the stand and are suppressing and deforming better formed younger trees. These cull trees may make up more than 25 percent

of the basal area per acre 5 inches and up, 40 years after logging.

(2). Many pole-sized trees (5 inches to 10 inches d.b.h.) left during the original logging were injured by logging or subsequent sunscald as a result of severe exposure. These trees are now culls or near-culls. Other individuals in this size class have developed wolfish characteristics and are using more space in the stand than their form and quality entitles them to. Still others have developed multiple crowns, shortening their merchantable height and in addition subjecting them to probable snow or wind breakage.

(3). In many cases, undesirable species such as red maple and elm have increased so that they take up more than half of the growing space.

(4). Generally the stands are over-stocked for best growth, with a basal area per acre of 90 to 150 sq. ft.

The stands resulting from operations in which chemical wood as well as sawlogs were cut have most of the same objectionable features, but with the following differences:

(1). In these stands everything, including cull trees, down to about 6 inches d.b.h., was taken in the original cut. Such cull trees as are in the stand now developed from the small trees left after logging, and consequently, are not as large, or as numerous, as where sawlogs only were cut.

(2). Much of the stand consists of sprouts which, with the exception of basswood, have a tendency to be crooked, forked, defective in the butts, and generally of poorer quality than seedlings of the same species. Also, because sprouts have more rapid initial height growth than seedlings, many are becoming wolfish at the expense of the higher quality seedlings.

Two stands which exemplify the two conditions just described have been under observation at the Upper Peninsula Experimental Forest for 25 years. One stand was cut to remove all trees down to small cordwood size while in the other nothing under 12 inches d.b.h. was cut. In the first twenty years after cutting, the first stand grew back from $3\frac{1}{2}$ sq. ft. to 70 sq. ft. of basal area per acre 2 inches and up. During the same time it grew about 400 bd. ft. net of sawtimber.

The stand cut only for sawlogs grew from 26 sq. ft. to 94 sq. ft. of basal area per acre and from 400 to 3,000 net bd. ft. of sawtimber during the same period. This stand resembles an all-aged forest, while the first one is distinctly even-aged.

Intermediate and stand improvement cuts aimed at improving the quality and increasing the growth are long-time and continuing operations. Early in the life of the stand, such operations involve a cash outlay. When there

is no return in salable products, accordingly, they are seldom undertaken except on an experimental basis. As the stand becomes older, stand improvement work can be self-supporting under current market conditions.

Stand Improvement Practices Involving a Cash Outlay

Stand improvement practices for which the cost will be more than the income include cleanings, and some typesof improvement cuts, thinnings, and release operations.

Cleaning - When there is a considerable mixture of species present, there is an opportunity to improve the composition by favoring the more desirable kinds in cleaning operations. Seedlings can be favored over sprouts. This operation must be done when the stand is very young, usually before it is 10 years old, in order to release the more valuable less tolerant species.

Improvement Cuts - Cutting or otherwise killing old cull and wolf trees is clearly of benefit to reproduction and sapling stands. Wolf trees over a 10-year old sapling stand were girdled on an experimental plot on the Nicolet National Forest in Wisconsin to test the effect on the understory. It was found that the response was very satisfactory, especially where the culls were 15 inches and over. This operation should also be carried out early in the life of the stand, probably at the same time as the cleaning operation. Any of the overstory trees that contain or give promise of yielding merchantable products should be left to help liquidate the cost of subsequent stand improvement work and to keep any all-aged character that exists.

Thinning - Dense sapling stands have been thinned successfully to improve form and increase growth. For economic reasons this is usually done on a crop tree basis. It is probably well to wait until the stand is between 15 and 20 years old before attempting crop tree selection as experimental results of selection at a younger age are contradictory. In Wisconsin, crop trees were selected in an 11-year old stand with 70 percent success 8 years later. However, on the Experimental Forest at Dukes, the opposite was true in a 16-year old stand. I believe, that crop tree selection can be successful when the dominant trees average $2\frac{1}{2}$ to 3 inches d.b.h.

The question of what radius to thin around the crop trees or what stocking level to thin to has not been adequately answered. If the thinning is too heavy, natural pruning is delayed while if it is too light, little growth response will result. It appears that a stocking of 85 to 90 sq. ft. of basal area of trees in the main stand is satisfactory. This would be about equivalent to a 5 foot thinning radius for trees 3 inches at d.b.h.

Release - On the basis of several studies, release of hardwoods from overstory of aspen and pin cherry is not recommended until the aspen is merchantable. The removal of the aspen did improve the growth of the understory, but not in a sufficient amount to justify the expense. Removal of pin cherry was found to be unnecessary. The cherry does not cast enough shade to slow down the understory growth appreciably.

Commercial Intermediate Cuts

After the stand reaches 35-45 years of age, it is usually possible to start periodic commercial improvement cuts and thinnings under present market conditions. This is especially true of stands originally cut for sawlogs only. If a market develops for hardwood pulpwood in the future, these cuts can be started about 10 years earlier (25-35 years of age). Where no previous intermediate cuts have been made, the objectives of these improvement cuts should be as follows:

(1). Remove the cull trees as rapidly as possible without creating excessively large openings that might lead to undesirable suckering or sprouting on the main stems of residual trees.

(2). Reduce poor growing stock in favor of well-formed thrifty trees in the understory and codominant stand.

(3). Thin thick patches of pole-sized trees to improve their growth and vigor.

(4). Where the stand permits, these cuts should aim at developing an all-aged structure in the stand.

An operation of the kind just mentioned proved to be profitable on the Argonne Experimental Forest. The sawlog material removed had an average stumpage value per thousand board feet, net log scale, of $18.00 to $20.00. The gross returns per acre were $25 to $30. But if there is no market for the products from the pole-sized material, their removal, through felling or girdling, will be an expense which will lower the financial return considerably; for it is essential to cut over the entire diameter range of the stand. Improvement in the growth and quality of the pole-sized trees is the prime objective of this type of cut.

Again it appears that a residual stocking of 85 square feet of basal area per acre will give the best quantity and quality growth, although there is little factual data on this matter as yet.

Second growth hardwood stands--especially where chemical wood was cut--primarily of sprout origin or so defective that little or no primary growing stock is present should be handled differently. The quality and value of the end product (probably No. 3 sawlogs) does not justify holding the stand to maturity. Although very little work has been done in this kind of stand, I believe it should be liquidated as soon as a seedling stand can be established in the understory and the materials removed can be marketed. This, probably, will have to be done by a series of partial cuts, heavy enough to permit the establishment of seedlings, but light enough to keep sprouting down to a minimum. These cuts probably should start at about age 45 and continue at 5 or ten-year intervals until the understory is established. At that time <u>all</u> the residual stand should be removed.

WHERE WE STAND TODAY

There is a great deal yet to be learned about managing northern hardwood stands in the Lake States, but we do have enough knowledge to help meet the major problem confronting us--how to bridge the gap between the time rapidly dwindling old growth stands are gone and the developing second growth stands have reached sawlog size. Briefly, this is what we must do:

(1). Cut the old growth stands by the selection system, aiming at a stocking of about 85 sq. ft. of basal area per acre (in trees 5 inches d.b.h. and larger), and carrying no trees beyond 23 inches d.b.h. unless they must be kept to maintain the stocking level. Remove cull trees as rapidly as possible.

(2). In second growth stands carry out stand improvement practices with the objective of producing a stand at 80 years which can be handled by the selection method. This may be illustrated by a schedule such as the following which could be applied to a recently logged clearcut northern hardwood forest:

At <u>ten years</u> of age, make a cleaning in the young growth and remove large cull trees through girdling, cutting, or poisoning.

At <u>twenty years</u> make a noncommercial thinning and release, either on a crop tree or general basis.

At <u>thirty years</u>, make an improvement cut which may break even.

From <u>40 to 80 years</u>, make commercial improvement cuts at ten-year intervals. These cuts will yield increasing financial returns.

Sometime <u>shortly after 80 years</u>, handle the stand for sawtimber under the selection system.